22. METAL FOUNDING,
In metal molds,
Ingots. Plants.

Metal No.
416.1

Ser. 28589 Ladle.

Fr. 158206.

164-126

FIG. 1.

FIG. 2.

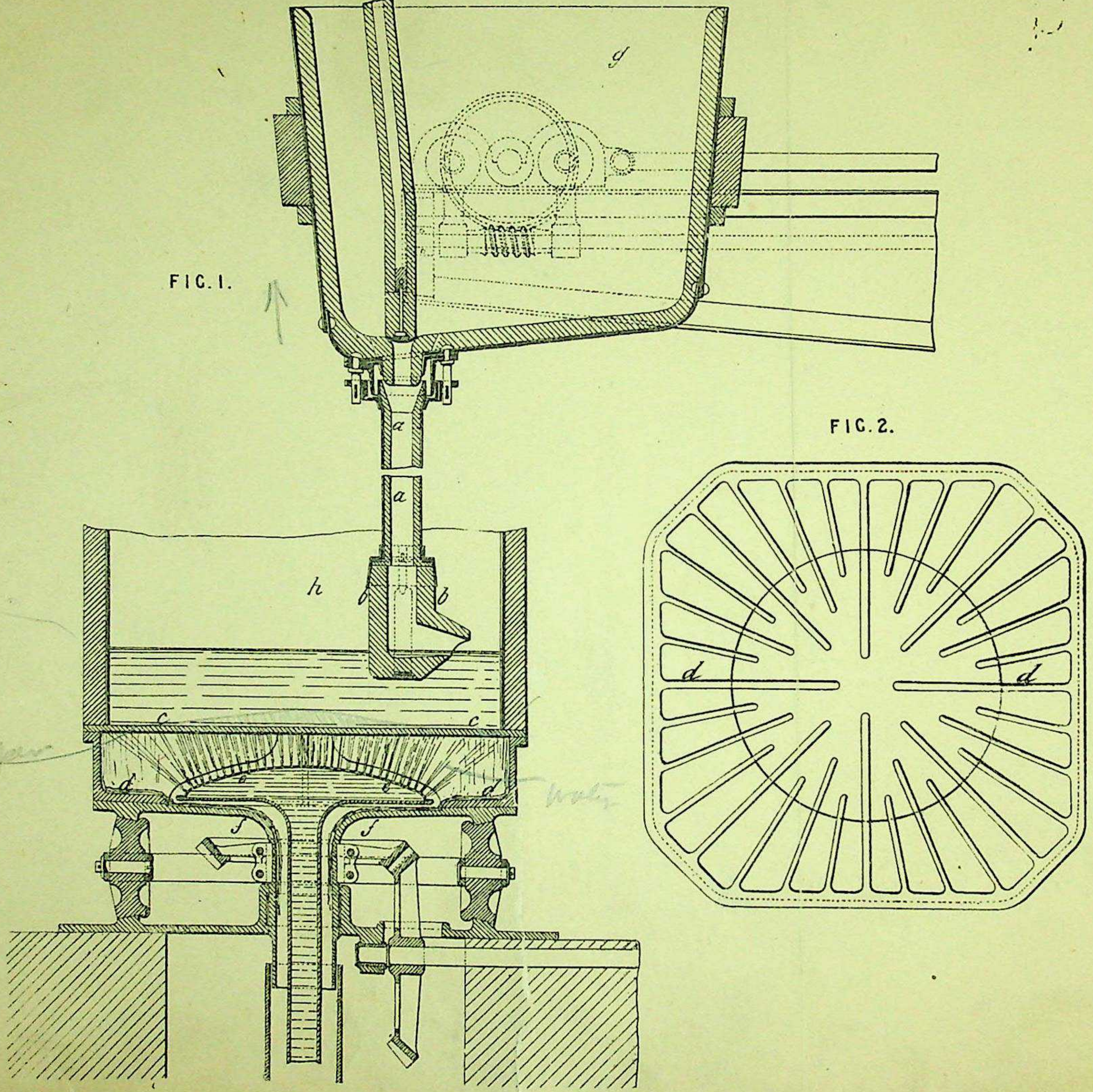


FIG. 3.

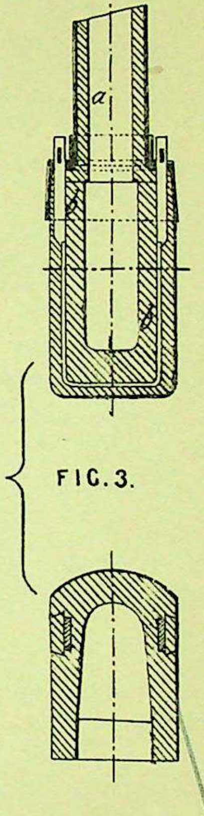
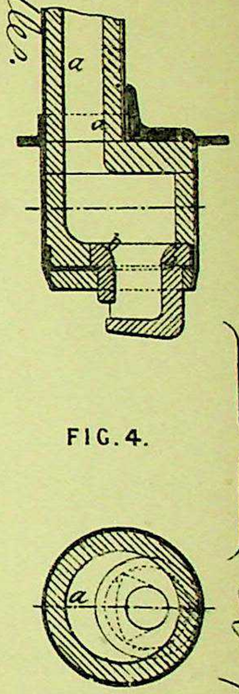


FIG. 4.



molding

A.D. 1884 Feb. 5 No. 2786.
Clark's Specification

a 786/84

A.D. 1884 Feb. 5, No. 2786
...ark's Provisional Specification

22. METAL FOUNDING,
In metal molds,
~~Ingots: Plants~~

FIG. 1.

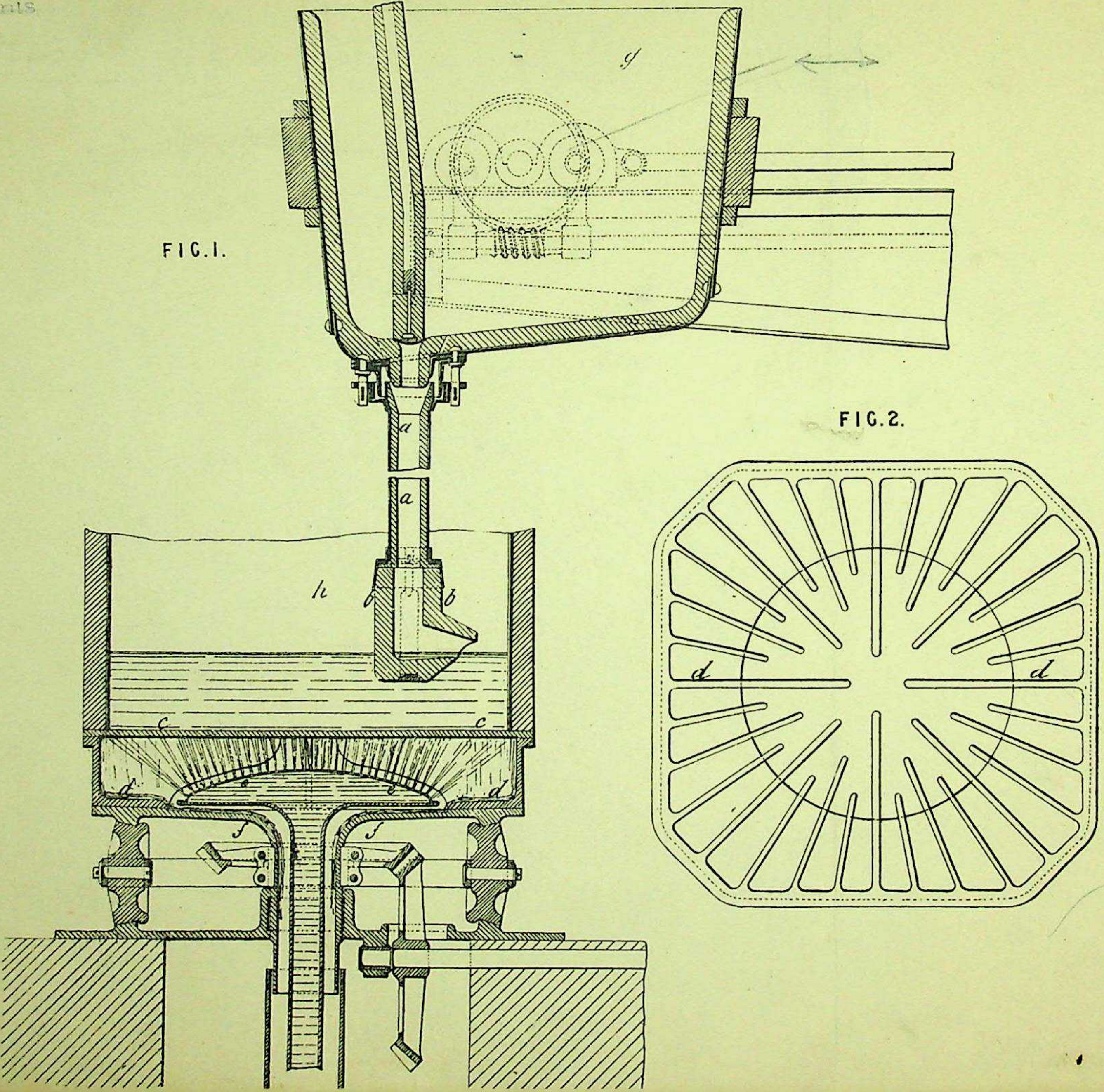


FIG. 2.

FIG. 3.

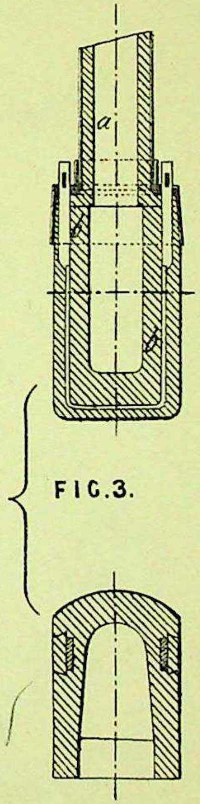
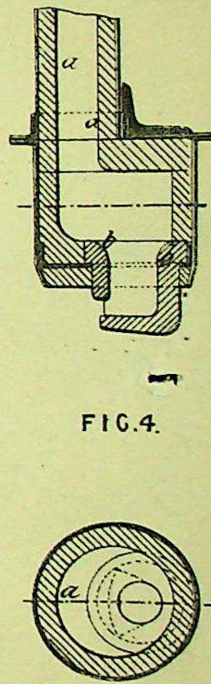


FIG. 4.



A114
Ingots; Plants

Copper bottom to a mould &c

A.D. 1884, *5th February.* N° 2786. D

Improvements in the Process and Apparatus for Casting Steel.

[*Communicated from abroad by Monsieur Brustlein, of Paris, France.*]

PROVISIONAL SPECIFICATION.

I Alexander Melville Clark of the firm of A. M. and Wm Clark of 53 Chancery Lane in the County of Middlesex, Fellow of the Institute of Patent Agents, do hereby declare the nature of the said Invention for "Improvements in the Process and Apparatus for Casting Steel" to be as follows:—

Notwithstanding the good results obtained from steel by mechanical tests it is liable when used for objects of large dimensions to give way suddenly the reason of which has not been determined.

These mysterious breakages may be attributed to imperfect casting of the ingot from which the defective objects were made.

In the manufacture of cast steel only small ingots were at first cast for which a clean surface was indispensable, and casting in small long ingot moulds of small section answered very well for this purpose without presenting any difficulties. The same method of working was afterwards applied to ingots of the largest dimensions.

The general method is to place the ladle holding the liquid steel above the mould so that the stream of steel falls vertically from the ladle into the ingot mould. But for large ingots, this manner of casting is absolutely defective. Without entering into detailed and lengthy explanations, the inconveniences of this mode of working are,

1st No provision is made for the proper contraction of the metal when cooling.

2nd The escape of the gas during solidification is impeded.

3rd An ingot is thus of necessity obtained, not homogeneous in chemical composition and texture, and presenting transverse and longitudinal lines of weakness the position and importance of which vary according to the nature of the metal and the conditions under which the casting was performed. These inequalities when very marked are the cause of the sudden subsequent breakages.

4th To obtain a perfectly satisfactory block of steel by this method of casting, a very large portion of the upper side of the ingot must be sacrificed.

This Invention has for its object to remedy these defects which can be all completely avoided by means of the arrangements for casting shown by way of example in the annexed Drawings.

[*Price 6d.*]

Figure 1 is a vertical central section of the general arrangement. Figure 2 is a plan of the supporting bed of the ingot mould. Figures 3 and 4 are sectional detailed views of the spoon or nose of the ladle.

The ladle *g* is carried by a crane, which ladle besides a raising, lowering, and circular motion has also a reciprocating horizontal motion to and from the crane pivot.

At the outside of the tapping hole of the ladle there is fixed a pipe *a* fitted at its lower extremity with a nose or spoon *b* both made of refractory material. This nose *b* is to change the direction of the stream by diverting it slightly upwards as shown in Figure 1, instead of allowing it to fall vertically on the bottom of the mould. The lower part of this nose is of a larger section than the tube itself so that the velocity of the stream will be diminished when entering the ingot mould *h* and prevent splashing at the commencement of the casting. The nose or spoon shown on the Drawing can be arranged in any other way which attains the same object. When the fall of the steel is considerable and the area of the tap hole of the ladle and pipe great, the nose or spoon might be broken by the blow from the falling steel and a bend or elbow would therefore be introduced and well supported in the tube above the nose or spoon and with an enlargement below the bend.

The bottom of the ingot mould *h* is formed of a plate of a good conducting [illegible] (copper for instance) 20 to 30 millimetres thick. This bottom rests [illegible] supporting frame of cast iron or other metal with radiating ribs, so close to [illegible] other as to support the bottom plate and prevent it buckling under the weight [illegible] steel. The ribs are of bracket form to allow room for a large rose *e* through which water is discharged under pressure, in order to cool the bottom of the mould during the process of casting. This plate can be thus kept so cool that there will be no steam generated during the operation of casting.

The ribbed frame *d* is fixed on a foundation plate *f* slightly conical in the centre for collecting the water and guiding it to the large central tube by which it is carried away. A circular motion is imparted to the foundation plate, ribbed frame and the ingot mould by bevel gear, the rose remaining fixed.

The apparatus works in the following manner.

The ladle containing the steel and the tap hole stopper being in position, the tube *a* is fixed below the tap hole and the ladle is drawn over the mould and lowered until the nose *b* is a few centimetres from the bottom of the mould. The latter is then set in motion, the water is turned on and the tap hole plug is raised to the full so that the flow of steel is abundant and in a few seconds covers the bottom of the ingot mould. After this the flow of steel is lessened gradually, the ladle is raised slowly, but not so quickly as the level of the steel rises, until the flow of metal from the nose takes place at the very surface of the steel in the mould. From this moment the ladle is raised at the same speed as the steel rises in the mould so that the flow of molten steel will be always in the plane of the surface of the molten metal. Moreover the flow of steel is regulated so that it shall always be at a suitable temperature at the surface of the bath, and the ladle can be moved backward and forwards so that the flow be more or less towards the centre or the sides of the mould according to the purpose of the object to be made from the ingot.

The casting ought to be so performed as to allow the steel to contract freely and therefore it ought to be cooled from bottom to top as regularly as possible. For hastening the cooling in the centre the holes in the middle of the rose are nearer together than at the circumference, and the water from them strikes more normally. To facilitate the contraction at the periphery in certain cases, the interior of the mould could be coated to a certain height with a light adherent refractory material well dried.

When the bottom of the mould is once covered with liquid steel, the flow of metal is moderated so that the cooling will be methodical upward and through the metal; this is not only favourable to contraction but also to the escape of gas which takes place during solidification. A very quick cooling by radiation is

produced by these arrangements at the surface of the bath in the ingot mould during the running as fresh layers of liquid steel are poured on the preceding already slightly cooled by radiation.

As the discharge orifice is always in part at least immersed in the liquid steel the flow may be moderated in great measure and to protect this orifice from cold the refractory material projects forward beyond or over it. The rotating motion can be more rapid at the commencement, till the bottom of the mould is covered with steel, but it must be so slow that the surface of the bath remains flat and horizontal. There might be some fear in working with water in the casting pit; but in this case it is as isolated from the pit and steel as that working the hydraulic crane.

As this apparatus enables the casting to be so performed that the steel in the centre of the ingot shall from the very commencement cool before the circumference, large surfaces can be covered without the ingot having the cracks in the bottom which are produced when casting by the ordinary method, ingots having a large transverse section.

The bottom of the mould is well supported and the metal falls on it with very little force, and in a different place at every moment and the plate is well cooled below.

The right is reserved of applying to the mould a truncated cone shaped bottom of a good conducting metal, copper or cast iron &c. The thickness of this bottom increasing towards the centre would produce by its considerable mass a cooling effect analogous to but not so effective as that produced by water. Remarkably compact ingots are obtained by this process, the metal contracting freely and more satisfactory results are obtained than by the most powerful compression. An ingot no higher than its diameter will present no interior contraction, and can be all used with security with the exception of the upper crust; the loss is thus reduced to a minimum. By taking the necessary precautions an ingot as deep as an ordinary ingot can be cast with much less contraction and a greater homogeniety than by any other processes. The ingots cast by this method are suited for objects of large dimensions or where great security is required, e.g.: boiler and ship plates; large crank shafts; screw shafts for steam vessels sections and bodies of cannons; railway tyres.

The system is adapted for the production of cast steel armour and particularly for compound armour produced by casting superimposed layers of steel of different hardness.

Dated this 5th day of February 1884.

A. M. & W^M CLARK.

COMPLETE SPECIFICATION.

I, ALEXANDER MELVILLE CLARK, of the firm of A. M. and Wm. Clark, of 53, Chancery Lane, in the County of Middlesex, Fellow of the Institute of Patent Agents, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN THE PROCESS AND APPARATUS FOR CASTING STEEL" and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Notwithstanding the good results obtained from steel by mechanical tests it is liable when used for objects of large dimensions to give way suddenly, the reason of which has not been determined.

These mysterious breakages may be attributed to imperfect casting of the ingot from which the defective objects were made.

In the manufacture of cast steel only small ingots were at first cast for which a clean surface was indispensable, and casting in small long ingot moulds of small section answered very well for this purpose without presenting any difficulties.

The same method of working was afterwards applied to ingots of the largest dimensions.

The general method is to place the ladle holding the liquid steel above the mould so that the stream of steel falls vertically from the ladle into the ingot mould, but for large ingots, this manner of casting is absolutely defective. Without entering into detailed and lengthy explanations, the inconveniences of this mode of working are,

1st No provision is made for the proper contraction of the metal when cooling.

2nd The escape of the gas during solidification is impeded.

3rd An ingot is thus of necessity obtained, not homogeneous in chemical composition and texture, and presenting transverse and longitudinal lines of weakness the position and importance of which vary according to the nature of the metal and the conditions under which the casting was performed. These inequalities when very marked are the cause of the sudden subsequent breakages.

4th To obtain a perfectly satisfactory block of steel by this method of casting, a very large portion of the upper side of the ingot must be sacrificed.

This Invention has for its object to remedy these defects which can be all completely avoided by means of the arrangements for casting shown by way of example in the annexed Drawings.

Figure 1 is a vertical central section of the general arrangement of the apparatus. Figure 2 is a plan of the supporting bed of the ingot mould. Figures 3 and 4 are sectional detailed views of the spoon or nose of the ladle.

The ladle *g* is carried by a crane, which ladle besides a raising, lowering, and circular motion has also a reciprocating horizontal motion to and from the crane pivot.

At the outside of the tapping hole of the ladle there is fixed a pipe *a* fitted at its lower extremity with a nose or spoon *b* both made of refractory material. This nose *b* is to change the direction of the stream by diverting it slightly upwards as shown in Figure 1, instead of allowing it to fall vertically on the bottom of the mould. The lower part of this nose is of a larger section than the pipe itself so as to diminish the velocity of the stream when entering the ingot mould *h* and prevent splashing at the commencement of the casting. The nose or spoon shown on the Drawing can be arranged in any other way which will attain the same object. When the flow of steel is considerable and the area of the tap hole of the ladle and pipe great, the nose or spoon might be broken by the blow from the

falling steel and a bend or elbow would therefore be introduced and well supported in the tube above the nose or spoon and with an enlargement below the bend.

The bottom of the ingot mould *h* is formed of a plate of a good conducting metal (copper for instance) 20 to 30 millimetres thick. This bottom rests on a supporting frame of cast iron or other metal with radiating ribs, so close to each other as to support the bottom plate and prevent it buckling under the weight of the steel. The ribs are of bracket form to allow room for a large rose *e* through which water is discharged under pressure in order to cool the bottom of the mould during the process of casting. The bottom plate can be thus kept so cool that there will be no steam generated during the operation of casting.

The ribbed frame *d* is fixed on a foundation plate *f* slightly conical in the centre for collecting the water and guiding it to the large central tube by which it is carried away. A circular motion is imparted to the foundation plate, ribbed frame and the ingot mould by bevel gear, the rose remaining fixed.

The apparatus works in the following manner: The ladle containing the steel and the tap hole stopper being in position, the tube *a* is fixed below the tap hole and the ladle is drawn over the mould and lowered until the nose *b* is a few centimetres from the bottom of the mould. The latter is then set in motion, the water is turned on and the tap hole plug is raised to the full so that the flow of steel is abundant and in a few seconds covers the bottom of the ingot mould. After this the flow of steel is lessened gradually, the ladle is raised slowly, but not so quickly as the level of the steel rises, until the flow of metal from the nose takes place at the very surface of the steel in the mould. From this moment the ladle is raised at the same speed as the steel rises in the mould so that the flow of molten steel will be always in the plane of the surface of the molten metal. Moreover the flow of steel is regulated so that it shall always be at a suitable temperature at the surface of the bath, and the ladle can be moved backward and forwards so that the flow be more or less towards the centre or the sides of the mould according to the purpose of the object to be made from the ingot.

The casting ought to be so performed as to allow the steel to contract freely and therefore it ought to be cooled from bottom to top as regularly as possible. For hastening the cooling in the centre the holes in the middle of the rose are nearer together than at the circumference, and the water from them strikes more normally. To facilitate the contraction at the periphery in certain cases, the interior of the mould could be coated to a certain height with a light adherent refractory material well dried.

When the bottom of the mould is once covered with liquid steel, the flow of metal is moderated so that the cooling will be methodical upward and through the metal; this is not only favorable to contraction but also to the escape of gas which takes place during solidification. A very quick cooling by radiation is produced by these arrangements at the surface of the bath in the ingot mould during the running, as fresh layers of liquid steel are poured on the preceding layers already slightly cooled by radiation.

As the discharge orifice is always in part at least immersed in the liquid steel the flow may be moderated in great measure and to protect this orifice from cold the refractory material projects forward beyond or over it. The rotating motion can be more rapid at the commencement, till the bottom of the mould is covered with steel, but it must be so slow that the surface of the bath remains flat and horizontal. There might be some fear in working with water in the casting pit; but in this case it is as isolated from the pit and steel as that working the hydraulic crane.

As this apparatus enables the casting to be so performed that the steel in the centre of the ingot shall from the very commencement cool before the circumference, large surfaces can be covered without the ingot having the cracks in the bottom which are produced when casting ingots having a large transverse section by the ordinary method.

The bottom of the mould is well supported and the metal falls on it with very little force, and in a different place at every moment and the plate is well cooled below.

The right is reserved of applying to the mould a truncated cone shaped bottom of a good conducting metal, copper or cast iron &c. The thickness of this bottom increasing towards the centre would produce by its considerable mass a cooling effect analogous to but not so effective as that produced by water. Remarkably compact ingots are obtained by this process, the metal contracting freely and more satisfactory results are obtained than by the most powerful compression. An ingot no higher than its diameter will present no interior contraction, and can be all used with security with the exception of the upper crust; the loss is thus reduced to a minimum. By taking the necessary precautions an ingot as deep as an ordinary ingot can be cast with much less contraction and a greater homogeneity than by any other processes. The ingots cast by this method are suited for objects of large dimensions or where great security is required, e.g.; boiler and ship plates; large crank shafts; screw shafts for steam vessels, sections and bodies of cannons; railway tyres &c.

The system is adapted for the production of cast steel armour and particularly for compound armour produced by casting superimposed layers of steel of different degrees of hardness.

Having now particularly described and ascertained the nature of the said Invention and in what manner the same is to be performed, I declare that what I claim is:—

1st In the manufacture of cast steel, the employment of a nose or spoon *b* for projecting the molten lead into the ingot mould from the ladle in a horizontal or nearly horizontal direction as and for the purpose specified.

2nd The combination with the ladle, of a pipe *a* having a nose or spoon *b* of larger section than said pipe to reduce the velocity at which the stream of molten metal enters the mould.

3rd The combination with the ingot mould *h* of the ladle *g* provided with a pipe for supplying the molten steel, said ladle having a rising motion so as to enable the point of delivery of the molten metal to be maintained at or about the surface of the bath as specified.

4th Imparting rotary motion to the ingot mould so as to direct the jet of molten metal towards the various parts of the bath, as described for the purpose specified.

5th The construction of revolving ingot mould for casting steel consisting (a) of a mould box lined with refractory material (b) a bottom plate *c* of sheet metal forming a good conductor (c) a metal frame *d* with radial ribs supporting the bottom plate *c* (d) a fixed rose *e* for discharging water under pressure against the bottom plate *c* for the purposes of cooling (e) a foundation plate *f* provided with a central water discharge and bevel gearing for imparting rotary motion to the ingot mould all arranged and combined as hereinbefore described for the purpose specified.

Dated this 10th day of September 1884.

A. M. CLARK.

By his Agents,
A. M. & Wm. Clark.

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For Her Majesty's Stationery Office.

1884.